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BULLETIN

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Electrical Safety: A Perspective on Operational Experience

Concern is growing within the Department of Energy (DOE) over a series of events that involved electrical shock to contractor employees at DOE facilities. Numerous deficiencies in electrical safety practices were identified by nearly all of the 35 Tiger Team Assessments. Although DOE is making progress in correcting electrical deficiencies at our facilities, the continuing electrical safety incidents indicate that more effort is needed to identify and correct root cause problems. The following data, obtained from DOE's Safety Performance Measurement System and Occurrence Reporting and Processing System identify the types of incidents that are occurring within DOE. DOE and its contractor employees are working together to strengthen DOE programs that protect the workplace from such hazards.

Findings

More than 2,300 Occupational Safety and Health Administration (OSHA) electrical safety findings have been documented by Tiger Team Assessments. Each of these compliance findings involving electrical safety (Title 29 Code of Federal Regulations [CFR] 1910 Subpart S, and 29 CFR 1926 Subpart K) represents a deficiency in, or the lack of, a requirement "necessary for the practical safeguarding of employees in their workplaces."

Direct Contact Injuries—Shocks and Burns

A number of DOE and contractor employees have been injured as a result of electrical shocks. Approximately 130 DOE or contractor personnel reported shocks or burns due to contact with electricity in the workplace from January of 1983 to October 28, 1992 (91 shocks, 39 burns). Although averaging only 13 direct-contact reports per year, the possible consequences of these electrical contacts must be kept in mind. Electrocution killed four people during the 9 1/2 years; a fifth death may have been the indirect result of an electrical shock. Three additional deaths that were related to electrical work, but were not the result of direct contact, will be discussed later.

The four electrocution deaths resulted from direct contact with high voltage circuits. Three of the four victims were Power Administration electricians; the fourth was an electrician at a fuel processing plant. All but one of the victims were aware that they were working on energized circuits. A fifth death resulted from a fall from an 85-foot high transmission line tower. It is believed that the fall was a result of the lineman coming in contact with an energized transmission line.

General categories of causes found in the shock and burn reports include:

- ◊ Contact with faulty (shorted) equipment (e.g., plugs, power tools, and welders).
- ◊ Improperly wired equipment.
- ◊ Failure to implement lockout/tagout procedures and/or use adequate protective equipment.
- ◊ Inattentiveness and carelessness, including:
  - use of uninsulated tools
  - use of wrong instruments/meters/tools
  - failure to pre-verify volt/amp meter operation
  - allowing tools to slip onto live circuits
  - wearing jewelry (e.g., rings, watches, bracelets) while working on live circuits.
- ◊ Manufacturers' defects and aging equipment.
- ◊ Inadequate procedures governing excavating and concrete cutting/drilling.
- ◊ Failure to recognize the dangers of large capacitors.

Over 1,200 lost work days (LWDs) were the result of shocks, while electrical burns accounted for nearly 300 LWDs. The severity of the shock and burn injuries correlates with the amount of voltage encountered; the higher the voltage the greater the consequences. It should be noted that a number of the injuries reported occurred, not as a consequence of the shock itself, but as a result of a fall after experiencing the shock.

As expected, workers in occupations most at risk from electrical shock and burns are electricians and technicians. This is due to the nature of their work (e.g., high voltage exposure, troubleshooting, and experimental designs). DOE electricians and technicians have experienced over 50 percent of the reported shocks and burns. Employees in other occupations, such as mechanics/repairers, welders, laborers/helpers, machinists, and those that use portable electric tools, are also more at risk than might be expected. In addition, personnel in occupations that require standing in water when performing their tasks (e.g., firefighters, janitors) tend to experience more shocks than do others.

Indirect Hazards—Electrically Initiated Fires and Explosions

Approximately 97 fires or explosions either caused by or involving electrical energy have been reported for the time period evaluated. Most of these events did not result in injury or death; however, one death and many injuries did occur. Electrically initiated fires and explosions accounted for losses totaling millions of dollars, as well as worker injuries. One event, alone, resulted in reported equipment damage of $3,465,000.

General categories of causes found in the fire and explosions reports include:

- ◊ Failure to include appropriate equipment in Preventative Maintenance (PM) programs.
- ◊ Failure to have an electrical safety program and/or implement established principles.
- ◊ Lack of knowledge by key individuals of the location of critical shut-off breakers and switches.
- ◊ Unattended energized equipment and appliances.
- ◊ Equipment age.
- ◊ Improperly sized overload devices/no lightning arrestors or voltage spike suppressor circuits.
- ◊ Inadequately trained and qualified high voltage electrical workers.
- ◊ Failure to develop work packages or require safe work/hazardous work permits for tasks involving energized high voltage circuits.
- ◊ Failure to fully implement lockout/tagout procedures.

Failure to implement lockout/tagout procedures resulted in the death of one worker and injury to another when an unlocked/untagged electrical solenoid valve was inadvertently opened, allowing natural gas to be released into the work area which subsequently ignited and exploded.

Those most at risk from electrically initiated fires and explosion are the workers in the immediate area (i.e., electricians, technicians, mechanics, etc.). However, fires that spread (and larger explosions) have the potential to affect others as well, including the firefighters charged with extinguishing the fires and the workers required to cleanup or return the system to an operable condition.

Other Hazards of Electrical Work

Two deaths involving electrical workers did not result from either direct electrical contact or a fire or explosion. These deaths were the result of 1) falling while removing old conduit from a building being decommissioned and 2) being crushed by a tree being felled near a power line. Although neither involved electrical safety issues per se, additional "general worker training" might have reduced the likelihood of these and other similiar incidents.

Recommendations

An excellent overview of electrical safety requirements can be found in 29 CFR Parts 1910.331 - 1910.335, "Safety-Related Work Practices." These five parts contain information on "qualified" vs. "unqualified" persons, training requirements, work practice selection, use of electrical equipment, and safeguards for personnel protection. If these requirements been followed completely by each applicable DOE organization or contractor, few, if any, of the 130 shock and burn injuries or deaths would have occurred.

Shock and Burn Recommendations

- ◊ Review programs for the inspection and/or repair of portable electrical equipment for completeness and effectiveness.
- ◊ Review policies concerning work permits on "live" circuits with a goal of reducing the frequency of such work.

- ◊ Emphasize electrical worker training in certain areas such as the following:
  - Lockout/tagout practices
  - Use of protective equipment
  - Use of insulated tools
  - Minimum approach distances
  - Meter selection/testing/use
  - Electrical rescue/CPR
  - Potential dangers involving metal tapes/"fish" tapes
  - Include a pre-task review of the following for supervision of selected electrical work.
  - Goals of the task
  - Task methodology (live vs. lockout/tagout)
  - Qualifications of assigned personnel
  - Proper instrumentation/tools
  - Adequate protective equipment and usage
  - Methods of preventing a fall should a shock occur
- ◊ Perform an inventory of energized electrical circuits with a goal of disconnecting unused circuits from the source and removing the wiring.

Fire and Explosion Recommendations

- ◊ Review electrical preventative maintenance programs to ensure all necessary equipment is included (e.g. connections).
- ◊ Identify old equipment and develop a program/ schedule to replace the identified equipment (e.g. transformers, large capacitors, ballasts).
- ◊ Know locations of critical shut-off and kill switches, and ensure that they are clearly identified.
- ◊ Check trailers and modular buildings for electrical panel quality and size, appliance loads, loose connectors, and faulty electrical heaters.
- ◊ Develop a program to ensure that all nonessential unattended appliances are turned off.
- ◊ Control all high voltage tasks with a work package that includes a hazardous/safe work permit.
- ◊ Protect deluge and sprinkler systems over switchgear, transformers, or other high voltage electrical equipment from accidental activation (e.g., manual control).
- ◊ Review the adequacy of the current number of lightning arrestors and/or voltage spike suppression circuits.
- ◊ Make fire extinguishers available at remote job sites and in all DOE vehicles.

General Recommendations

Employees should be provided training that covers information regarding electrical risks such as inadequate grounding and reverse polarity and likely electric shock producing equipment, including extension cords, plugs, and portable power tools. The dangers of energized and unattended appliances should be stressed in this training, as well as the theory behind lockout and tagout procedures. Employees working with electricity should also be informed on how to recognize electric shock victims, safe methods of rescue, and cardio-pulmonary resuscitation.

DOE Electrical Safety Task Group

At the direction of the Under Secretary, the Assistant Secretary for Environment, Safety and Health established a task group to immediately review electrical safety programs and practices across the DOE complex. The task group, led by EH with representatives from the Offices of Defense Programs, Environmental Restoration and Waste Management, Energy Research, and Nuclear Energy, will identify measures to improve and ensure electrical safety of DOE and contractor employees. A status report and preliminary findings from the group will be provided to the Under Secretary by November 30, 1992.

This Bulletin is one in a series of publications issued by EH to share occupational safety information throughout the DOE complex. To be added to the Distribution List or to obtain copies of the publication, call (615) 576-3482.

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